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Renewability of products assessed using emergy

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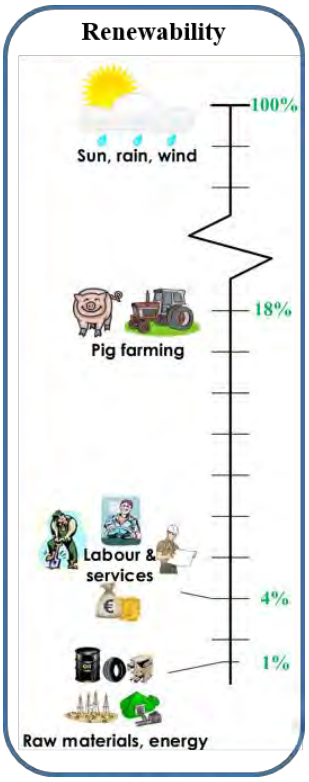
Often products are claimed to be 'green' and sustainable without being backed up by a scientifically rigorous understanding of sustainability. Sustainable development implies making use of largely renewable resources. Thus, a sustainability assessment must identify hotspots for reducing the use of non-renewable resources and the potentials for substitution of these with the three natural renewable energy flows. These flows are solar radiation (including wind and rain), deep earth heat and tidal energy. Emergy assessment (EmA) provides tools for such hotspot analyses distinguishing on-site, local and global renewable resources[1]. Emergy is defined as the total available energy (exergy) directly or indirectly required to make a product or service[2]. It is accounted in solar equivalent joules (seJ). EmA is a kind of life cycle assessment which is are largely based on the same type of inventory of energy and material flows as standard LCA, but which applies different theories of values and system boundaries. LCA draws system boundaries around the studied system as supported by purely human dominated processes (resource extraction, refining, transportation etc.), whereas EmA in addition considers processes occurring in natural systems and, thereby, includes all direct and indirect flows of freely available resources such as the sun, rain and wind. Another difference is that EmA includes labour in order to take into account the indirect resources from society, e.g. infrastructure, needed to support the system[3].



EmA will be demonstrated with focus on estimating the renewability of bioenergy from a combined heat and power (CHP) plant co-fired with willow chips[4]. The inventory includes material, energy and labour inputs classified as renewable or non-renewable (see figure) for the life cycle stages production, transport and combustion of willow. The study is based on inputs for growing willow under commercial conditions in Denmark with pig manure as fertilizer. The resources used for producing the pig manure are included as the idea of regarding an input as 'waste' is against the principles of EmA[4].

Despite the popular understanding of bioenergy as 'renewable energy', the analysis shows that in fact, only 16% of the resource use may be traced back to the natural renewable energy flows. Hotspots for non-renewable emergy flows are the pig farming providing the fertilizer and the costs of externalities.

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[2] Odum H.T. 1996. Environmental Accounting: Emergy and Environmental Decision Making. Wiley and Sons.
[3] Kamp A, Morandi F., Østergård H. 2013. Development of concepts for human labour accounting in Emergy Assessment and other Environmental Sustainability Assessment methods. Ecological Indicators 60: 884-92.
[4] Kamp A, Østergård H. 2013. How to manage co-product inputs in emergy accounting exemplified by willow production for bioenergy. Ecological Modelling 253: 70-8.